SECTION 5. CERTIFICATION TEST PROCEDURES

5.1 GENERAL

These test procedures are an integral part of the BAR-97 EIS specifications and have been developed to ensure that the systems proposed for use in the California I/M program comply with certain minimum requirements of state and federal law and regulation. Additional testing will be performed by BAR staff to determine conformance with the goals of the program, the intent of the legislation, and the specification. Verbal agreements with BAR staff are non-binding.

In addition, if it is determined that any item or section of the BAR-97 specifications has not been tested, BAR reserves the right to modify the certification test procedures to insure compliance with the BAR-97 specifications.

MANUFACTURERS / THIRD PARTY DEVELOPERS NOT IN GOOD STANDING WITH BAR WILL NOT RECEIVE IMMEDIATE ATTENTION UNTIL OUTSTANDING DEFICIENCIES ARE CORRECTED.

The following rules apply to BAR Certification:

1. BAR Certification:
   Applicable only to complete EIS systems. As a result of certification and beta-site testing, a BAR-certified system has been found to be in full compliance with the BAR-97 Specification. Any flaws subsequently found during field use shall be corrected by the EIS manufacturer in a timely manner that is satisfactory to the BAR.

2. Provisional BAR System Approval:
   A partial certification that may be awarded to an EIS manufacturer in the event that its EIS has passed most of the requirements for BAR certification, but that one or more modifications, additions or corrections (listed in the Provisional BAR System Approval) are still necessary. These modifications, additions or corrections are of such a nature that, in the judgment of BAR Engineering, little doubt exists of their successful implementation (e.g., typographical corrections, representation of data on screen, screen prompts, etc.)

3. BAR Component Approval:
   Applicable to dynamometers, analyzers, and devices that integrate with a BAR 97 system. This approval may include provisional clauses.

4. BAR Device Approval:
   Applicable only to devices such as zero air generators which can be used in conjunction with EIS without requiring software/hardware integration with the system.

5. BAR Aftermarket Parts Approval: (refer to Section 6)
   Applicable to aftermarket parts such as probes, sample hoses, filters, bar code scanners, and tachometers. BAR approval states that the components meet the applicable portions of the BAR-97 Specification, and are thus suitable for direct sale to Smog Check stations (aftermarket parts only) or eligible for integration into an EIS by the EIS manufacturer (computers and other major components).

The candidate shall be tested using the procedures specified below. In addition, as a condition of initial certification, the units shall undergo field *(beta)* testing to verify the performance, *accuracy*, reliability and "user-friendliness" of the systems in the actual garage environment. The units may be rejected for user unfriendliness or for any function, prompt or entry that the BAR feels would induce incorrect or inaccurate entries. The BAR will identify or approve licensed Smog Check stations that may be candidate sites for field-testing**.** ***Note: See Section 4.9 of this specification for certification terms, conditions and renewal requirements.***

The following paragraphs describe the standard instruments, and the testing, recording and reporting requirements.

5.1.1 Certification Requirements

a) All of the tests in this section shall be performed by the manufacturer, and all the certification criteria shall be met.

b) A Certification Test Report shall be prepared, and included in the certification submittal package.

c) A certification submittal package shall be prepared along with an application for certification, and one copy shall be submitted to the BAR. Additional copies must be provided if requested by the BAR.

d) Three EIS units and applicable peripheral equipment shall be provided to the BAR for testing at its laboratory facilities at 10240 Systems Parkway, Sacramento, CA. Five to ten units and applicable peripheral equipment shall be made available for field testing in the Sacramento area. Field testing may be, at BAR's discretion, performed concurrently with BAR lab testing or after completion of the lab testing. It is recommended that a spare unit be readily available (i.e., within two hours') in the event that a problem develops during the BAR laboratory testing or field testing. To expedite verification testing, BAR may require additional units at its laboratory.

e) All EIS designs must meet the intent of the specification.

f) The manufacturer shall certify to the BAR that their EIS design meets or exceeds the performance specifications of this document.

g) With respect to the electronic transmission of test data to the BAR VID, manufacturers shall demonstrate, to the BAR's satisfaction, full system compatibility, including successful diskette, port, and modem transfer of files to the VID.

h) The proposed hardware configuration must be fully supported by all software and/or operating systems listed in this specification. Performance tests to prove compatibility will be required.

i) All equipment and software submitted for certification must be the full and current configuration proposed for sale. PARTIAL, DATED, OR INCOMPLETE MODELS ARE NOT ACCEPTABLE.

j) The manufacturer will be responsible for all shipping and equipment preparation charges for the certification testing.

k) The BAR shall charge a fee for certification/approval testing of the BAR-97 and related components and parts. The certification fee shall only cover one (1) round of testing, additional testing will require additional fees. The fee shall be fixed by the department based upon its actual costs of certification testing, shall be calculated from the time that the equipment is submitted for testing until the time that certification testing is complete, and shall in no event exceed the dollar limit specified in §44036(b) of the Health and Safety Code. In any event, the initial deposit is $10,000 for certifying a EIS or $5,000 for approving any other BAR-97 component such as dynamometer or analyzer/sensor, or $2,000 for a device approval. The initial deposit for certification/approval of a replacement part depends on the extent of the required testing.

If the manufacturer's application for certification is complete and acceptable, and is substantiated by evaluation tests (from this specification) conducted by the manufacturer or an approved laboratory, the BAR will certify that specific model subject to its verification testing. That model will then be acceptable for sale and use in licensed stations in California.

During the course of the program, the BAR may, at its discretion, direct the manufacturer to retest at his expense any production model from the manufacturer's supply to verify that quality control standards are being met. Should the retest indicate substandard quality or nonconformance with the technical specifications, it shall be the manufacturer's responsibility to recall and correct or replace, at his expense, all defective units. At the

BAR's discretion, certification/approval may be withdrawn if deficiencies and problems are not expeditiously corrected.

It is the BAR's intent that no deviations in the performance requirements be granted. If, in order to comply, a candidate would require a major cost increase on an item that is in no way related to performance, a waiver request may be considered and should include the following:

1. Reason for the request.

2. Description of the deviation from the design specifications.

3. The effect of the deviation on overall compliance of the EIS.

4. Extent and impact of corrective action required to modify the EIS if the waiver is not granted.

5. Delivery of a sample unit to the BAR for demonstration purposes.

Allow at least 30 days from the BAR's receipt of the waiver request and demonstration unit to receive approval or disapproval.

5.1.2 **Certification Submittal Package**

a) The submittal package for EIS certification shall contain the documentation listed below. Appendix F provides a submittal requirement reference for other submittal types such as hardware or software modifications and aftermarket replacement parts.
   - Application for certification
   - EIS description
   - Software documentation
   - Certification test report
   - Instruction manual
   - Business and financial report
   - Organization chart

b) The submittal package and its contents will be treated by the BAR as confidential, and will be kept secured.

c) In addition to a hard copy of the certification submittal package documentation, manufacturers shall provide an electronic copy in the form and format specified by the BAR.

5.1.2.1 **Application for Certification**

A completed Application for Certification form must accompany the certification submittal package at the time the EIS is submitted for certification. The BAR will make a preliminary review of the EIS and certification submittal package before formally accepting the application for certification.

5.1.2.2 **Candidate Description**

a) Operation: Furnish a complete description of the candidate and its operation including descriptive brochures (proof copies acceptable) of the units.

b) Specifications: Submit performance, mechanical, power, weight and dimensional specifications for each model. For analyzers, include zero drift lockout threshold (see §2.4.5 b).

c) Price List: Submit a base retail price list for each model and a price list of optional accessories available to the purchaser.

d) Schematics and Photographs: Detailed mechanical, electrical drawings and schematics shall be submitted of the entire EIS and its components, if applicable. Color 8 x 10 photographs of the sample handling and filtering system, analyzer section, enclosures, nameplates, sensors, displays, keyboard/controls, dynamometer and gas calibration instruction plates shall be provided in the package.

e) Instruction Manual: A complete instruction manual (proof copies acceptable) for each model unit shall be submitted. The manual shall contain, as a minimum, all items specified in Section 4 of the Specification. Each step of the operating and calibrating procedure shall be verified by the manufacturer.

f) Components, Devices and Aftermarket Replacement Parts: Required descriptive information is also required. See Section 6 of this specification

5.1.2.3 **Software Documentation**

a) The BAR-97 software shall be fully documented. One copy of the documentation listed below shall be submitted to the BAR unless otherwise requested. Manufacturers shall agree, in writing (signed by the CEO of the company), to submit copies of the program listings to the BAR upon request, within a time frame satisfactory to the BAR, or whenever a decision is made by the manufacturer to voluntarily suspend or terminate production of the BAR-97. **The BAR does not expect to ever have a need to review the program listings and therefore, will not require that they be included with the application for certification. However, the BAR reserves the right to require that copies be provided, if the need does arise.** Software documentation shall include at least the following:

1. Complete program listings, including the source code as well as the object code, in both machine-readable and paper form, shall be provided upon request. They are not required to be submitted with the application for certification.
2. Functional specifications.
3. Functional flowcharts of the manufacturer's software routines and subroutines. These flow diagrams shall include decision points and decision/timing criteria so that the logic of the programming can be correlated, where applicable, to the specification.
4. Sample inputs and outputs from all processes.
5. Detailed interface information on the optical bench including the identification of protocol and output specifications.
6. All OS file layouts with file names, file types and file security.

b) Documentation provided by the manufacturer to meet this requirement will be treated as proprietary information by the State provided such material is clearly marked as confidential. Gross marking of all material as confidential is not acceptable. Mark only that material which is proprietary.

The purpose of the requirement for detailed code is to provide the State with a mechanism to assure continued performance of Smog Check stations using BAR-97s in the event that a major supplier should fail or withdraw from the program. The State is not interested in sharing proprietary information, or the detailed inner workings of manufacturer's software code. However, it is essential that all of the necessary working codes, schematics, and drawings be available in case of such demise or withdrawal.

5.1.2.4 **Certification Testing**

a) The data establishing the performance and technical capabilities of the EIS shall be included in a test report prepared by the manufacturer or a BAR-approved commercial laboratory. Confirmation of the test data will be made by the BAR. Components, Devices & Aftermarket Replacement Parts: submittals shall comply with the requirements of this section as applicable.

b) The manufacturer shall certify that the EIS submitted for certification complies with all applicable California and Federal administrative, safety, ergonomic, licensing, and certification requirements. Ignorance of the law is no excuse for noncompliance.

Manufacturers shall utilize a testing laboratory or laboratories meeting BAR approval. The manufacturers may perform the required testing themselves. The manufacturers shall supply the BAR with the following specific information before submitting their application for certification:

1. Safety Laboratory:

   i. Description of the laboratory's capabilities, including the types of testing commonly performed there;

   ii. Description of the laboratory's facilities, including size, location and specialized facilities, such as electromagnetic interference (EMI) rooms;

   iii. Description of the laboratory's test instrumentation, including manufacturer, model number, accuracy, and frequency of calibration;

   iv. Description of the laboratory's testing and follow-up procedures.

2. Functional Testing Laboratory: In addition to the requirements of items i, ii, and iii above, the following information must be provided:

   i. Credentials of the staff that will be performing the tests at the selected laboratory;

   ii. A statement from the person in charge of testing at the lab and the manufacturer's representative witnessing the tests, certifying that all tests were performed and that they were performed in the manner required in the specifications.

   iii. A description (i.e., brand names, model numbers and list of specifications) of the equipment used to perform the tests contained in this specification.

3. The BAR recommends that manufacturers collect the required information and forward it to the BAR before initiating any testing to ensure that we are satisfied with the laboratory chosen.

   If the BAR is familiar with the Safety Laboratory and/or the Functional Testing Laboratory, and the BAR's information is current, these informational requirements may be waived.

5.1.2.5 **Business Status**

a) Financial and Business Information: Manufacturers and distributors shall submit information with their request for certification, including the following:

   1. Evidence that the applicant is a bona fide manufacturer or distributor of emission inspection systems (exhaust gas analyzers, dynamometers, fuel

cap testers and other internal/integral devices). As a minimum, include an approximate number of products of the type for which certification is requested that have been manufactured and sold.

2. Evidence that the applicant possesses sufficient insurance to cover product liability claims, and secured funds for prepaid warranty or service contracts.

3. Evidence that the applicant is either a California corporation or out-of-state/foreign corporation registered to do business in California.

4. Annual sales volume during the most recent fiscal year for all products including exhaust gas analyzers and dynamometers.

5. Manufacturing capacity dedicated to, or available for, producing the EIS, including number of manufacturing personnel and size of factory.

6. Total assets, total liabilities and net worth of the applicant at the time of the most recent quarterly report. To qualify, the financial statement shall show that the manufacturer's net worth is at least $2,000,000 for full EIS manufacturers and $1,000,000 for dyno manufacturers (if dyno submitted separately). The BAR may consider bonds or additional insurance to supplement a portion of the monetary requirement. In addition, the BAR may accept deposit of monies (a portion of each unit sold) into an escrow account to be used exclusively for replacement of defective systems. However, any equivalent proof of financial soundness must be presented to the BAR for its approval.

7. The most recent annual or quarterly report of publicly held corporations may be substituted if it contains all the same information.

b) Marketing/Training Plan: The marketing plan shall include statewide distribution methods and a training plan to cover all new EIS purchasers and designated trainees. The scope of the training plan shall encompass the system's use as an inspection and diagnostic tool, steps in performing gas calibrations and leak checks, dynamometer operation, safety and calibration, preventative maintenance and recognition of malfunctions requiring assistance of a manufacturer's service representative.

The EIS manufacturer shall be capable of providing units for delivery within 180 days after certification has been granted or within 30 days after acceptance of an order from a customer.

c) Servicing Products (see Section 4): The manufacturer's statewide service network shall be such that each EIS marketed can obtain service within a reasonable time. Warranty response provisions shall be listed.

In addition, service facilities shall be located throughout California at locations that ensure reasonable access by all purchasers. Each EIS manufacturer will provide a permanent company representative within the state to control and ensure continued quality maintenance of their product.

5.1.2.6 **Organization Chart**

An organization chart listing the names and titles of the key persons involved with the development, testing, sales and service for the BAR-97 emission inspection systems, including regional and local sales and service staff throughout California and a telephone and address directory for those persons.

5.1.3 **Changes to Test Requirements**

The BAR may, at its option, add, modify or delete certain test and/or documentation requirements. Any changes will be based on such factors as questionable validity, excessive cost, implementation problems, or unforeseen problems with EIS (candidate or standard), equipment or procedures. Manufacturers will be notified and, if necessary, requested to run the modified tests at their testing facility.

5.1.4 **Certification Test Report**

The certification test report shall include the following:

a) Table of contents

b) Introduction: Include a description of the candidate EIS from a hardware and functionality standpoint, a description of the test facilities and equipment used, and the rationale for the testing sequence employed and any tests which were combined.

c) A list of all tests performed, including repeated tests, in chronological order. Reference the ***BAR-97 Specification*** paragraph number of each test, and include pass/fail results.

d) A list of all failures encountered, including which candidate failed, test during which the failure occurred, cause of failure, repairs performed.

e) A list of adjustments and component replacements, including tests during which they were performed and the reason why they were performed.

f) Completed data sheets. Out-of-specification data shall be clearly noted on the data sheets, by color, asterisk, or other device, along with percent deviation, where:

$$\% \text{ Deviation} = \frac{(\text{Test reading} - \text{std. value})}{\text{Std. value}} \times 100\%$$

g) Certification by an official of the manufacturer that the instructions and other information in the operator's manual are correct and complete, both in fact and in sequence.

h) Certification by an official of the manufacturer that the data in the Certification Test Report are the actual test data taken during testing to the requirements of these procedures.

5.1.5 **Failure Criteria**

At least two of the three candidate EIS must pass all tests with no adjustments or service except as permitted or required by the individual test procedures. Failure of a component constitutes failure of that individual EIS. The component may be replaced and the testing continued if the manufacturer's failure analysis confirms that:

a) The failure is not related to the EIS design.

b) A reliability study predicts that the service life of the failed component or system is consistent with the certification period.

c) The validity of the test data will not be affected by replacing the component.

Example of failure: Any type of dynamometer mechanical or electrical problem, or sample system failure (other than replacing or cleaning particulate filters) constitutes a failure of the individual EIS. The same criteria for replacement and test continuance apply as for components.

If any one of the three criteria above cannot be met, the certification testing must begin again as necessary to ensure at least two of the three candidate EIS are in full compliance.

5.1.6 **Termination Policy for Certification Testing**

IF THE BAR ENGINEERING STAFF IDENTIFIES 10 OR MORE DEFECTS, TESTING WILL BE TERMINATED AND THE AFFECTED MANUFACTURER WILL BE REQUIRED TO RESUBMIT ITS APPLICATION FOR BAR-97 CERTIFICATION. TESTING WILL COMMENCE AFTER MANUFACTURERS RESUBMIT THEIR APPLICATIONS AND ARE SCHEDULED INTO THE NEXT TEST CYCLE. DEFECTS ARE DEFINED AS MISSING OR NONFUNCTIONAL REQUIREMENTS, OR FUNCTIONAL FEATURES WHICH DO NOT OPERATE IN STRICT ACCORDANCE WITH THE BAR-97 SPECIFICATIONS AND THE

ASSOCIATED ADDENDA. TYPOGRAPHICAL ERRORS, MISSPELLINGS, INCORRECT GRAMMAR, ERRONEOUS FORMATS OR OTHER SUCH DISCREPANCIES WILL NOT CAUSE THE TESTING TO BE TERMINATED, BUT WILL STILL HAVE TO BE CORRECTED BEFORE CERTIFICATION IS GRANTED.

5.2 CERTIFICATION TEST PROCEDURES FOR BAR-97 - GENERAL

a) **Candidate Units**

The tests shall be performed on three candidate units, each of which shall be of production configuration. Minor deviations, cosmetic in nature, may be allowed by the BAR.

b) **Standard Instruments**

Where appropriate (see individual test procedures), candidate EIS readings shall be compared with the readings of laboratory-grade analyzers such as the Horiba 200 Series NDIR, chemiluminescent, and paramagnetic analyzers or equivalent. Each standard instrument shall be individually characterized for accuracy, repeatability, response time, etc., before certification testing is begun.

c) **Gases**

Span gases and gases used for accuracy, response time and other tests shall be high purity, 2% blend tolerance, with a manufacturer-certified accuracy of 1.0% of the concentrations shown on the cylinder label. "Quad-blends" of propane, CO, CO_2 and NO in nitrogen shall be used rather than blends of the individual gases with nitrogen, except as otherwise specified in the individual test procedures.

d) **Recorders**

Where required, analyzer outputs shall be recorded by analog or digital strip chart or equivalent recorders equipped with event marking capability, or by data acquisition systems sampling at a minimum rate of 10 Hz. If strip chart recorders are used, each analog record shall note the chart speed and the scale (i.e., volts per division). Event marking shall be used to record the start and finish of test intervals to fully substantiate report data. Digital recorders shall sample at a minimum rate of 10 Hz. (Note: ASM testing (see §5.4.12) shall sample and record data at a 1 Hz rate.) Copies of desired records will be made available to the BAR on request. All records, analog or digital, shall identify, at a minimum, the candidate EIS, the test performed, date, ambient temperature, humidity and barometric pressure.

e) **Fuel**

In cases where the test procedures require sampling vehicle exhaust, the vehicle shall be fueled with commercially available gasoline.

f) **Test Sequence**
The sequence of performing the tests is left to the testing organization's discretion, except as otherwise noted. Where possible, the testing organization may combine tests to their best advantage, while ensuring that valid data is collected for all tests.

5.3 CERTIFICATION TEST PROCEDURES FOR BAR-97: SAMPLE CONDITIONING SYSTEM

The EIS evaluation procedures below are designed to determine candidate EIS compliance with the technical provisions of the other sections of this document.

5.3.1 Exhaust Sampling Hose

a) Crush Test: Place the sample hose on a concrete floor. Drive a vehicle weighing at least 4,000 lbs over the hose twice at a rate of 3 - 5 mph and in a direction perpendicular to the hose.

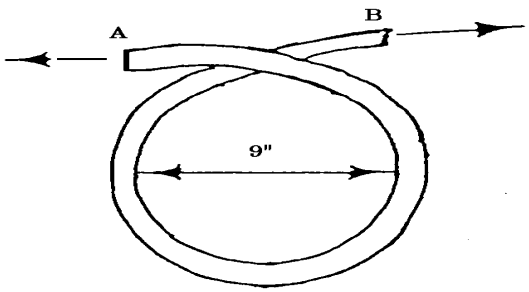
Acceptance Criteria: The candidate hoses shall exhibit no permanent deformation or kinking. They shall quickly return to their original shape and cross-section. They shall show no evidence of any test-induced defect or abnormality, such as a collapsed core or separated layers.

b) Flexibility Test: In a temperature-controlled chamber, stretch each candidate hose out in a straight line and restrain the ends so that the hoses cannot curl. The hoses shall remain in the chamber at a stabilized temperature of $60^{o}F \pm 5^{o}F$ for three hours. At the end of this period, lay one end of the hose on the floor of the chamber, leaving it unrestrained in any way. Holding the other end, coil the entire hose into as tight a coil as possible.

Acceptance Criteria: Each candidate coil shall have a maximum diameter of 24 inches.

c) Kink Test: Form a portion of each candidate hose into a 9-inch diameter loop (see figure below). Grasp hose at points A and B and pull so as to tighten the loop and force a kink.

Acceptance Criteria: Candidate hoses shall roll out of the loop, rather than be forced into a kink.



5.3.2 **Hose and Probe:**

a) Temperature Test

This test verifies the ability of the sample hose and probe to withstand the high idle exhaust gas temperatures produced by converter-equipped vehicles. Adjust the engine of a catalytic converter-equipped vehicle so that the tailpipe temperature is $1100^{o}F \pm 100^{o}F$ within 16 inches of the exit. (It may be necessary to run the vehicle on a dynamometer to reach this temperature.)

With the candidate EIS unit on and sampling, insert the sample probe fully into the tailpipe.

Sample the exhaust gas while monitoring the temperature for 5 minutes.

Remove the probe from the tailpipe and examine the hose and probe for any signs of permanent damage, such as charring, melting, weakness, permanent change in flexibility, separation of layers, or any change in overall functioning. To examine the interior of the hose, it will be necessary to cut it open at a point within 1 to 1½ inches from its connection to the probe.

> **Acceptance Criteria:** No signs of permanent damage or change in functionality. No changes that would be considered detrimental to the life expectancy of the hose or probe.

b) Flow Balance Test

This test verifies that the auxiliary hose and probe arrangement (for use with vehicles having dual exhaust systems) complies with the provisions of §2.12 of this specification.

1. Measure the length of the main sample hose between the end of the probe to the auxiliary hose fitting

Acceptance Criterion: The length shall be at least 7 feet.

2. Measure the length of the auxiliary hose.

Acceptance Criteria: (1) The length shall be at least 7 feet. (2) The length of the auxiliary hose shall be within ±3 inches of the probe-end-to-fitting length of the main hose.

3. Connect the auxiliary sample hose to the quick-connect fitting in the main sample hose. Connect flexible-tip probes to both the main hose and the auxiliary hose. Connect identical flowmeters to the probe inlets. With the EIS in Manual Mode and the sample pump running, measure the flow rates through the main and auxiliary paths.

Acceptance Criterion: The flow rate through the auxiliary hose shall differ by no more than 10% from the flow rate through the main hose path. This relative difference shall be calculated using the formula

Rel. Diff., % = 100 x (A – M)/M,
A = the flow through the auxiliary path,
M = the flow through the main path.

4. Remove the flexible tip from the auxiliary probe and replace it with the manufacturer's straight tip. Repeat Step 3 and use the same acceptance criterion.

5.3.3 **Sample System Leaks**

The sample system shall be tested for leaks prior to performing any of the certification tests that follow.

a) **Sample System:** Perform a sample system leak check using the manufacturer's instructions.

NOTE: If the method of checking for leaks is based on gas introduction through the probe, the gas pressure at the probe inlet shall be 0 ±0.1 psig.

Acceptance Criteria: Per manufacturer. Repair any leaks found and repeat the leak check until the sample system shows no more leakage.

Flow High Range BAR-97 calibration gas through the probe. Gas pressure at the probe inlet shall be 0±0.1 psig. Record the readings. Using a needle valve teed into a line upstream of the sample pump inlet, introduce a leak which reduces the readings by 1% (e.g., if the reading was 8.00% CO, the new reading would be 7.92% CO). Perform a leak check following the manufacturer's instructions.

Acceptance Criteria: The candidate unit (1) shall fail the leak check and (2) shall not allow an inspection to be performed.

b) **Integral Calibration Gas Control System:** With the EIS unit's calibration gas flow control valve in the off position, open the cal gas cylinder valve. Shut the cylinder valve off when the downstream pressure gauge on the cylinder regulator has stabilized. Monitor the pressure for 10 minutes.

Acceptance Criteria: There shall be no perceptible loss of pressure.

Visually check all tubing and connections between the cal gas flow control valve and the sample cell(s) of the optical bench.

Acceptance Criteria: There shall be no signs of loose fittings or tubing, and no signs of defective or damaged fittings or tubing.

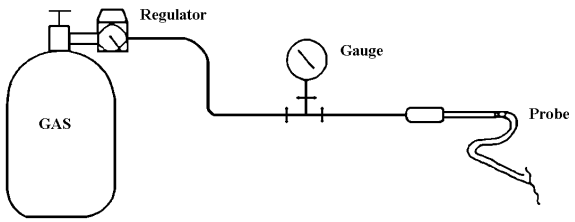
5.3.3 **Flow Sensitivity:**

1. Sample System Variations

This test characterizes the effect of variations in pressure differential/flow upstream of the sample pump on gas readings.

a) Gas calibrate the EIS.

b) Connect the regulator outlet of a cylinder of Mid Range #2 BAR-97 audit gas (see §2.4.5.i) to the inlet of a throttling valve, connect the outlet of the valve to a tee and then from the tee to the sample probe inlet. Connect a pressure/vacuum gauge, capable of reading ±5 psig to the last tee opening. (See figure.)



c) Open the gas cylinder valve and adjust the gas flow (using the cylinder regulator and the throttling valve) so that the inlet pressure to the probe is 0 psig ±0.1 psig. Let the readings stabilize, then record them.

d) Adjust the gas flow so that the inlet pressure to the probe is +1.5 psig ±0.1 psig. Let the readings stabilize, then record them.

e) Adjust the gas flow so that the inlet pressure to the probe is -1.5 psig ±0.1 psig. Let the readings stabilize, then record them.

f) Repeat Steps c), d) and e) two more times.

Acceptance Criteria: All gas readings shall differ by no more than 1% of each other.

2. Calibration Gas Path Variations

This test characterizes the effectiveness of the EIS calibration gas regulation as the calibration gas cylinders are emptied.

a) Disconnect the EIS's calibration gas cylinders. Connect a cylinder of high range audit gas to the EIS high range cal port using a length of high-pressure (400 psig minimum rating) hose and a CGA-165 adapter to connect to the EIS's regulator inlet. Connect a cylinder of low range audit gas to the EIS low range cal port in a similar manner. [NOTE: The cylinder regulators used with the audit gas cylinders shall be dual-stage, compatible with the audit gas blends, with a delivery pressure range of at least 5 psig to 200 psig and capable of delivering at least 10 liters per minute of gas blend.] ***DO NOT disturb the adjustments on the EIS regulators.***

b) Set the audit gas regulators to deliver 160 psig. Perform a standard gas calibration.

c) Perform a 4-gas audit, following the procedure in §2.4.5 i). Record the HC, CO, CO_2 and NO readings.

d) Set the audit gas regulators to deliver 30 psig. Perform a standard gas calibration.

e) Perform a 4-gas audit, following the procedure in §2.4.5 i). Record the HC, CO, CO_2 and NO readings.

Acceptance Criteria: The relative difference between the audit readings taken at 30 psig delivery pressure and those taken at 160 psig delivery pressure shall not exceed 1%, using the formula Rel. Diff., % = 100 x $(R_{30} - R_{160})/R_{160}$, where R_x is the audit reading when the EIS was calibrated with a delivery pressure of x psig. ***[NOTE: For the low range audit gas, the Acceptance Criteria shall***

be: HC < 3ppm propane; CO < 0.01%; CO2 < 0.1%; NO < 8 ppm. For Midrange #1 audit gas, CO2 < 0.1%; HC, CO and NO shall meet the 1% relative difference criterion.]

5.3.5 **Flow Restrictions**

a) Using a Mid Range #2 BAR-97 audit gas entering the sample probe at atmospheric pressure, take a base reading with no restriction in the line. Insert a throttling valve in the vacuum side of the sampling system. With the gas flowing (still at atmospheric pressure), restrict the sample flow until (1) the low flow indication is activated, (2) the system response time of the slowest NDIR channel exceeds 11 seconds to 90% of the base reading, or (3) the actual gas reading differs from the base reading on any channel by more than 3% of the base reading.

Acceptance Criteria: The low flow indication is activated and the system response times of all NDIR channels are 11 seconds or less to 90% of the base readings, and the actual gas readings differ from the base readings by 3% of the base readings or less.

b) If the low flow sensor is activated by pressure (or vacuum), insert a 0-10 psig (0-30 in. Hg) gauge between the throttling valve and the inlet to the low flow sensor. Use the throttling valve to activate and deactivate the low flow indication. Measure the pressure (vacuum) at which activation and deactivation occur. Perform this test three times.

Acceptance Criteria: The difference between the activation and deactivation point shall be no greater than 3% of the activation point (pressure or vacuum).

5.3.6 **Particulate Filter**

Install a new particulate filter per the manufacturer's instructions and perform a leak check. Adjust a 3.0L or larger engine to produce an exhaust gas hydrocarbon concentration of 1000-1200 ppm. Sample the exhaust gas for two hours or until the low flow indication is activated.

Acceptance Criteria: The low flow indication shall not be activated at any time during or at the end of the two-hour test period.

Note: This test must not be performed before the successful completion of the flow restriction test.

5.3.7 **Hydrocarbon Hangup**

With a new particulate filter installed, zero the analyzer. Insert the candidate unit's sample probe in the tailpipe of a vehicle whose eight-cylinder idling engine is emitting

between 600 and 700 ppm HC. After sampling the exhaust gas for one minute, remove the sample probe from the tailpipe. Holding the probe in clean air, time the drop in the HC reading. Make three such tests, allowing at least three minutes between each complete test. These three minutes shall commence at the end of the preceding test, after the reading has dropped to 20 ppm or the timer has reached 20 seconds, whichever comes first. The sample hose must be 25 ft ± 0.5 ft measuring from the front of the analyzer.

Acceptance Criteria: For each complete test, (1) the HC reading shall decay to 20 ppm or less within 20 seconds. (2) Inspection testing shall be locked out until the HC reading drops to 7 ppm or less.

5.3.8 **Probe Antidilution**

This test evaluates the ability of candidate antidilution device to (a) prevent dilution of the sample, and (b) allow no dilution when testing certain vehicles of the mid-seventies having noise baffles in their tailpipes.

a) **Antidilution:** Use a test vehicle whose engine size is between 1.3 and 1.8 liters, and which idles between 650 and 850 RPM. The test vehicle's tailpipe shall have an outer diameter of between 1.25 and 1.5 inches.

1. With the engine at normal operating temperature, and normal idle speed, de-tune the engine to produce at least 1000 ppm HC or 5% CO.

2. The candidate unit shall be properly adjusted and warmed up, operating in the Manual Mode with the Dilution Correction OFF and Ten-Second Moving Average selected. Insert the standard probe into the tailpipe to its full insertion depth of 16 inches. Record the stabilized average HC, CO, CO_2, NO and O_2 readings.

3. Withdraw the probe to 4 inches and record the stabilized average readings.

4. Repeat steps 2, 3, and 2 again.

5. Average the (2) stabilized average readings for each channel, average the (3) stabilized average readings for each channel, and subtract the (3) average from the (2) average.

6. For units provided with an antidilution device, repeat steps (2) through (5) using the antidilution device.

Acceptance Criteria: The difference found in (5) if no antidilution device is provided, or (6) if one is provided, shall be within the accuracy requirements specified in §2.4.5 j).

b) **Noise Baffles:** Use a test vehicle with at least one noise baffle in its tailpipe.

Acceptance Criteria: The standard probe (or antidilution device, if provided) shall demonstrate its ability to pass through the holes in the noise baffle(s) to its full insertion depth of 16 inches, or shall meet the acceptance criteria of (a) above with insertion to the depth of the baffle screen.

5.3.9 **Dilution**

a) Set vehicle with 1.6 liter maximum engine displacement at factory-recommended idle speed, OEM configuration exhaust system transmission in neutral, hood up (a blower to cool the engine may be used if needed). Set idle speed not to exceed 920 RPM. (Set for 900 RPM with an upper tolerance of 20 RPM.)

b) With a laboratory grade analyzer system, sample the exhaust at 16 inches depth with a flow sample rate below 320 liters per hour. Allow sufficient time for this test. Record all HC, CO, NO and CO_2 readings.

A chart recorder may be used to detect the point of stable readings.

c) Set the EIS in the Manual Mode with Dilution Correction OFF and Ten-Second Moving Average selected. Record the stabilized average HC, CO, CO_2, NO and O_2 readings. Use these readings for the computations in (e) below.

d) Repeat (b).

e) If the difference of the stabilized average readings between parts (b) and (d) exceeds 2% of the average of (b) and (d), repeat parts (b), (c) and (d); otherwise average (b) and (d) and compare with (c). If (c) is within 2% of the average of (b) and (d), then the equipment meets dilution specifications.

Acceptance Criteria: The flow rate of the EIS unit shall not cause more than 2% dilution during sampling of the exhaust of a 1.6L engine at normal idle. Two-percent dilution is defined as a sample of 98% exhaust and 2% ambient air.

5.4 CERTIFICATION TEST PROCEDURES: ANALYZER

5.4.1 Storage Temperature Conditioning

This preconditioning operation demonstrates the ability of the candidate units to meet the storage temperature requirements of the specifications. This test shall be performed before proceeding with the remaining tests. Each unit shall be stabilized at an ambient temperature of -4°F for at least three hours with power off, followed by a three-hour soak

at +130°F. At completion of these soaking temperatures, re-stabilize the unit to approximately 75°F before continuing with the tests.

5.4.2 **Temperature Stability**

This test will be run continuously until completed in the sequence shown. Any deviation or failure will require that the test be redone.

a) Stabilize the units at an ambient temperature of 75°F ± 5°F for at least two hours, with power and pump on.

b) Gas calibrate the units using the standard BAR-97 blends for HC, CO, CO_2, NO and O_2. Flow Mid Range #2 BAR-97 audit gas through the units and record the readings.

c) Lower the ambient temperature to 50°F ± 5°F and stabilize the units for two hours, leaving the power on and pump running. Readjust zero only as necessary, then reintroduce the audit gas WITHOUT ADJUSTING THE UNITS (gas calibration is not permitted). Record the readings.

d) Raise the ambient temperature to 100°F ± 5°F and stabilize for at least two hours leaving the power on and pump running. Readjust zero and electronic span only as necessary. Reintroduce the audit gas (gas calibration is not permitted). Record the readings.

e) Return the unit to 75°F ± 5°F and stabilize. Adjust zero, introduce the audit gas and record the readings, showing error as percent of reading.

> **Acceptance Criteria:** When gas calibrated at 75°F, the difference between the highest and the lowest readings, regardless of temperature, shall not exceed 3% of reading.

5.4.3 **Controlled Ambient Conditions**

All subsequent analyzer performance tests (unless otherwise noted) shall be conducted at each of the following ambient conditions in the sequence shown:

a) 75^{o} F ($\pm 2^{o}$F).
b) 110^{o} F ($\pm 2^{o}$F), 80% (±5%) relative humidity.
c) 35^{o} F ($\pm 2^{o}$F), 80% (±5%) relative humidity and 10 mph wind.

5.4.4 **Warm-up Time**

a) Prior to the warm-up test, unit power shall be off and the unit shall have been stabilized at the selected environmental test condition for a minimum of two hours. The unit shall then be turned on, warmed up, zeroed and gas calibrated, then turned off for a minimum of six hours.

b) Upon completion of this stabilization period, unit power shall be turned on. For each candidate unit, record the time interval between Power On and System Ready indication. Verify that, during this time interval, the emissions analyzer is prevented from performing an inspection, and that no exhaust readings of any kind can be made.

c) Perform an automatic zero, enter the Manual Mode (Dilution Correction and Ten-Second Moving Average both OFF), and sample BAR-97 Low Range calibration gas through the probe. Gas entering the probe shall be at room atmospheric pressure. Record the zero and span gas readings for each channel.

d) Wait five minutes. Do <u>not</u> perform any adjustments. Record the zero reading, feed BAR-97 Low Range calibration gas through the probe, and record the gas reading.

Acceptance Criteria:

(1) Warm-up time of the complete system shall not exceed 30 minutes from "power on" to "system ready" at <u>all temperature</u> conditions. The unit is considered warmed up as soon as the zero and span readings for each channel (a) have drifted less than the accuracy tolerances listed in §2.4.5.j) over a five-minute interval without adjustment, and (b) are within these accuracy tolerances of the zero and gas cylinder values;

(2) The system lockout and system ready features shall demonstrate their proper functioning during the analyzer warm-up period.

5.4.5 **Drift Tests**

a) **Zero Drift**

The zero drift test shall be conducted immediately following completion of the warm-up test, and is essentially a continuation of it. Units which cannot display negative values shall be monitored directly at the signal outputs of the bench, or at some other position in the signal path where negative values can be monitored. Record the readings for each channel at five-minute intervals for one hour after warm-up. The first reading (time = zero) shall be the first ***zero*** reading taken after the unit completed its warmup cycle; the second reading (time = 5 minutes) shall be the second ***zero*** reading taken during the warmup test. During this test, zero adjustments are allowed at t = 30 minutes and t = 60 minutes. (NOTE: zeroing shall not occur at any time during a Smog Check). All components such as motors, pumps and lighting shall remain on during the one-hour test.

Acceptance Criteria: (1) Drift over the one-hour period shall not exceed the accuracy tolerances listed in §2.4.5 j). (2) No cyclical variation with a period less than 10 minutes shall have a peak value of more than 1.5 times these accuracy tolerances.

b) **Span Drift**

This three-hour test shall be conducted simultaneously with the zero drift test.

Sample BAR-97 Low Range calibration gas through the probe every five minutes for the first 30 minutes, every 10 minutes for the second 30 minutes and every 15 minutes for the second and third hours. The first reading (time = zero) shall be the first gas reading taken after the unit has completed its warmup cycle; the second reading (time = 5 minutes) shall be the second reading taken during the warmup test. The gas pressure shall be room atmospheric at the entrance to the probe.

Electronic zero adjustment is permissible at t = 30 minutes, 60 minutes, and 120 minutes. Zeroing shall not occur at any time during a smog check. Components such as pumps, motors and lighting shall remain on for the duration of the test.

Acceptance Criteria: (1) Span drift shall not exceed the accuracy tolerances listed in §2.4.5 j) during the first hour. (2) Span drift shall not exceed 2/3 of these values or two least significant display digits, whichever is greater, during each of the second and third hours.

5.4.6 **Analyzer Accuracy and Bias**

This test confirms the ability of the candidate units to read various concentrations of gases within the tolerances required by this specification.

This test shall be performed after completion of the drift tests. The candidates shall be zeroed and gas calibrated using the BAR-97 High and Low Range calibration gases. The units shall be tested using blends of propane, carbon monoxide, carbon dioxide and nitric oxide in nitrogen, and oxygen in nitrogen, blended to 1% certified accuracy, in the following concentrations:

- 4500 ppm propane, 12.00% CO, 18% CO_2, 4500 ppm NO, 25% O_2
- 0%, 20%, 40%, 60%, 80% of these concentrations
- 500 ppm propane, 1.2% CO, 6% CO_2, 800 ppm NO, 5% O_2
- 0%, 10%, 20%, 40%, 60%, 80% of these concentrations
- 80 ppm propane, 0.20% CO, 3% CO_2, 200 ppm NO, 1.0% O_2
- 0%, 20%, 40%, 60%, 80% of these concentrations.

Alternatively, the fractional concentrations may be achieved using a gas divider.

a) Introduce the gases in ascending order of concentrations beginning with the zero gas (nitrogen). Record the readings of the candidate units to each concentration value.

b) After the highest concentration has been introduced and recorded, introduce the same gases to the candidate analyzers in descending order, including the zero gas. Record the response of the analyzers to each gas. Record negative values of zero, if any.

c) Repeat Steps (a) and (b) for the candidate units four more times, for a total of five.

d) **Calculations:**

1. Calculate the mean ($\bar{x}$) and standard deviation of each candidate's readings for each concentration. Include both upscale and downscale readings for the same gas concentration. (All calculations may not be possible for zero readings.)

2. For each concentration, compute the following:

$$y_1 = \bar{x} + K_{sd}$$
$$y_2 = \bar{x} - K_{sd}$$

Where K_{sd} = standard deviation x 1.24 (for zero and highest concentration value), or
K_{sd} = standard deviation x 0.715 (for all other concentration values)

3. Compute the uncertainty of the calibration curve for each concentration as follows:

U_1 = concentration value - y_1

U_2 = concentration value - y_2

Acceptance Criteria:
(1) For each concentration, the mean (0) shall be no greater than the tolerances in the table below. Note that these tolerances are root-sum-square values accounting for such variables as test and calibration gases.

Channel	Tolerance
HC	±3.40% or ±5ppm, whichever is greater
CO	±3.32% or ±0.03% CO, whichever is greater
CO_2	±3.54% or ±0.4%, whichever is greater
NO	±4.25% or ±27ppm, whichever is greater
O_2	±5.26% or ±0.2% O_2, whichever is greater

(2) U_1 - U_2 shall be no greater than the tolerance spread allowed in the table above.

5.4.7 **Hexane/Propane Conversion Ratio (75°F only)**

a) Calibrate the units per the manufacturer's instructions, using gas blends having propane as the hydrocarbon.

b) Sample a BAR-97 Low Range tri-blend having hexane as the hydrocarbon. Record the readings.

c) Sample a BAR-97 High Range tri-blend having hexane as the hydrocarbon. Record the readings.

Acceptance Criteria: The HC readings taken in Steps (b) and (c) shall not differ from the associated cylinder values by more than 4 ppm (Step b) or 48 ppm (Step c).

5.4.8 **Gas Interference**

This test examines the effect of non-interest gases on the analyzer channels. Testing shall be performed under the ***35***°F, 75°F and ***110***°F conditions, except as noted below.

a) Zero and span the candidate units.

b) Sample the following gases for at least one minute. Record each channel's response to the presence of these gases. The list below does not imply a sequence; the gases may be used to challenge the analyzer in any order.

	Interfering Gas
16%	Carbon Dioxide in Nitrogen
1600 ppm	Hexane in Nitrogen
10%	Carbon Monoxide in Nitrogen
3000 ppm	Nitric Oxide in Nitrogen
75 ppm	Hydrogen Sulfide in Nitrogen
75 ppm	Sulfur Dioxide in Nitrogen
9%	Carbon Monoxide and 18% Carbon Dioxide in Nitrogen
	28 ppm each Benzene, Toluene, Xylene in O_2-free N_2 (NDUV technology only)
	Water-Saturated Hot Air

NOTE: The water-saturated hot air shall be drawn through the probe from the top of a sealed vessel partially filled with water through which ambient air will be bubbled. The water shall be maintained at a temperature of 50°C ±5°C. THIS TEST SHALL BE PERFORMED AT THE 75°F AND THE ***110*** °F CONDITIONS ONLY.

Acceptance Criteria: (1) No gas or vapor in the above list shall cause a change in reading of more than the excursions allowed in §2.4.5 o) on any channel. (2) Immediately after the water vapor test, there shall be no evidence of condensation anywhere in the sample inlet tubing to the analyzer sample cell. (3) The actual CO and CO_2 readings when sampling the collision-broadening test gas (9% CO, 18% CO_2) shall be within the tolerances specified in §5.4.6.3.

c) **Quench Effects (NO and O_2 channels only. Not applicable to NDUV.)**

1. Connect a cylinder of N_2 to the balance gas side of a gas divider, and the interference gas cylinder of 3000 ppm NO in N_2 to the other side.

2. Record the NO channel readings at 0% on the gas divider, 20%, 40%, 60%, 80%, 100%.

3. Connect the interference gas cylinder of CO (for electrochemical cells; CO_2 for chemiluminescent sensors and NDIR) to the balance gas side of the gas divider, leaving the interference gas cylinder of 3000 ppm NO in N_2 connected to the other side.

4. Record the NO channel readings at 100% on the gas divider, 80%, 60%, 40%, 20%, 0%.

5. For each dilution level, calculate the relative error,

   E_R, % = 100 x (Readings from Step 4 - readings from Step 2)/(readings from Step 2)

6. Repeat Steps 3 through 4.

7. Repeat Steps 1 through 6 using a cylinder of zero air in place of the cylinder of NO.

   Acceptance Criteria: For each gas, for each dilution level, the E_R shall be no more than 1% of point.

d) **Saturation Effects (NO and O_2 channels only)**:

1. Flow NO interference gas through the analyzer and record the stabilized NO reading.

2. Flow the CO (or CO_2) interference gas through the analyzer for three minutes.

3. Flow NO interference gas through the analyzer again, and record the stabilized NO reading.

4. Calculate E_R for the readings recorded in Steps 1 and 3.

5. Repeat Steps 1 through 4 using zero air in place of the NO interference gas.

6. Repeat Steps 1 through 5 using the H_2S, SO_2 and H_2O (see Step 7) interference gases in place of the CO (or CO_2) gas.

7. Unlike the other interferents, water and water vapor are not swept out of the sample system quickly. To correct for this, perform Step 1; then with a dew point meter measuring the moisture in the sensor's exhaust, bubble N_2 through water at 50°C (122°F) to the analyzer until the measured dew point has been stable for 30 seconds. Finally, perform Step 3 and also record the dew point reading. From standard steam tables, determine the partial pressure of water vapor at the dew point temperature. Divide the H_2O partial pressure by the barometric pressure to determine the fraction of water vapor in the sample. Multiply the dry NO reading recorded in Step 1 by (1 – the fraction); this is what the wet reading should be to compensate for the moisture fraction in the sample. The actual wet reading, when compared to the calculated wet reading, shall meet the Acceptance Criteria below.

   Acceptance Criteria: In no case shall E_R exceed 1% of point.

5.4.9 **Voltage Variations**

This test examines the effects of variations in AC line voltage on EIS readings.

a) Perform a gas calibration on the candidate units with the line voltage at 115 volts AC.

b) Sample a BAR-97 Mid-Range #2 audit gas blend through the probe. Gas pressure shall be zero psig (room ambient atmospheric) at the entrance to the probe. Record the readings.

c) Adjust the line voltage to 127 VAC while continuing to sample the gas. Record the readings.

d) Adjust the line voltage to 103 VAC while continuing to sample the gas. Record the readings.

e) Adjust the line voltage to 115 VAC while continuing to sample the gas. Record the readings.

Acceptance Criteria: Readings shall not vary more than a of the accuracy requirements in §2.4.5.j), or two least significant digits of resolution, whichever is greater, over the entire voltage variation.

5.4.10 **Pressure Compensation**

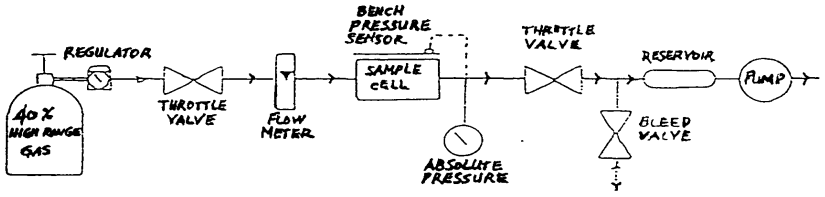
This test examines the precision of the candidate unit's pressure compensation system in keeping the readings constant over swings in barometric pressure. Two methods are used to compensate for pressure variations. One involves monitoring ambient barometric pressure; the other involves monitoring sample cell pressure. The following test procedure applies to both.

a) Insert a flowmeter at the sample cell inlet. To avoid unnecessary flow restriction, the flowmeter shall not have an integral needle valve.

b) Sample room air through the probe. Measure and record the flow rate.

NOTE: BEFORE PROCEEDING, DETERMINE THE MAXIMUM RECOMMENDED SAMPLE CELL PRESSURE FROM THE BENCH MANUFACTURER. BE SURE TO AVOID EXCEEDING THIS VALUE DURING TESTING.

c) Disconnect the tubing between the sample system and the flowmeter inlet. Install a throttling valve upstream of the flowmeter, and a source of BAR-97 Mid-Range #2 audit gas with a low-pressure regulator upstream of the throttling valve. At the sample cell discharge, tee in the bench's pressure sensor (if not already there) and a pressure gauge capable of reading 0-32 inches Hg absolute. Follow this with a second throttling valve, a reservoir of about 125 cu. in. (2 liters), and a vacuum pump with a bleed valve at its inlet. See the figure below.



d) Adjust the gas flow and the two throttling valves (and the vacuum pump and/or the bleed valve, if necessary) to produce the flow rate found in Step (b) and an exhaust pressure of 29.0± HgA. Adjust the readings to agree with the cylinder values.

e) Readjust the system to maintain the flow rate at a pressure of 31± HgA. Record the readings.

f) Readjust the system to maintain the flow rate at a pressure of 27± HgA. Record the readings.

g) Readjust the system to maintain the flow rate at a pressure of 26± HgA. Adjust the readings to agree with the gas cylinder values.

h) Readjust the system to maintain the flow rate at a pressure of 28± HgA. Record the readings.

i) Readjust the system to maintain the flow rate at a pressure of 24± HgA. Record the readings.

j) Repeat Steps d) through i) using 6% O_2 in N_2.

Acceptance Criteria: (1) The difference between the readings in Steps (d), (e) and (f) shall be no greater than the allowable accuracy tolerances in §2.4.5 j) of this specification. (2) The difference between the readings in Steps (g), (h) and (i) shall be no greater than the allowable accuracy tolerances in §2.4.5 j) of this specification. (3) The above criteria apply to the results of Item j).

5.4.10 (Alt) **Pressure Compensation – Alternate Method**s

Some sensors cannot be given a valid pressure compensation test by the above method. The following procedures apply to all designs.

a) *Barometric Pressure Chamber:* A pressure chamber large enough to house the units under test may be used. The procedure specified above shall be used; however, it is not necessary to use the above setup. Instead, flow Mid #2 audit gas through the EIS sample probe using the adapter with balloon. Adjust the ambient pressure in the chamber in accordance with the above procedure. Record the readings as above

b) *Altitude Method:* If such a chamber is not available, the units under test and the necessary test equipment will need to be driven by truck to the various altitudes.

i. Equipment needed:
- The units to be tested.
- BAR-97 Midrange #2 audit gas
- An AC generator to power the units to be tested.
- A large fan, such as those used to cool the engines of vehicles undergoing an ASM test.
- An adapter with balloon (and spares) to feed the gases from the

audit
cylinders into the sample probes of the units to be tested.
- Power cables, wrenches, etc.
- A truck or other means of transportation. (No trailers.)

ii. At an altitude or pressure equivalent of <100 feet, perform a leak check and a gas calibration.

iii. Zero the units and introduce the Mid #2 audit gas to the sample probe through the adapter with balloon. (The balloon should be erect, but not inflated.) Record the readings on the data sheets on the first "<100 feet" row.

iv. At the altitude or pressure equivalent of 3000 feet, turn on the units to be tested (if they are not already running) and allow them to warm up. Wait another 15 minutes before testing. Zero the units and introduce the Mid #2 audit gas to the sample probe through the adapter with balloon. (The balloon should be erect, but not inflated.) Record the readings on the data sheets on the "3000 ft" row.

v. Calibrate the units, then Reintroduce the Mid #2 audit gas.. Record the audit readings on the "3000ft (+ cal)" row.

vi. At the altitude or pressure equivalent of 7000 feet, turn on the units to be tested (if they are not already running) and allow them to warm up. Wait another 15 minutes before testing. Zero the units, but do not calibrate. Introduce the Mid #2 audit gas to the sample probe through the adapter with balloon. (The balloon should be erect, but not inflated.) Record the readings on the data sheets on the "7000 ft" row.

vii. At the altitude or pressure equivalent of <100 feet, turn on the units to be tested (if they are not already running) and allow them to warm up. Wait another 15 minutes before testing. Zero the units and introduce the Mid #2 audit gas to the sample probe through the adapter with balloon. (The balloon should be erect, but not inflated.) Record the readings on the data sheets on the last "<100 ft" row.

Acceptance Criteria: For each channel, the absolute and relative differences between the highest reading recorded in Steps v., vi., and vii. above and the lowest reading shall be as follows:

Channel	Relative Error, %	Absolute Error
HC	3%	4.0/PEF ppm C_3H_8
CO	3%	0.02% CO

CO_2	3%	0.3% CO_2
NO	4%	25 ppm
O_2	5%	0.1% O_2

5.4.11 **Analyzer/Sensor Response Time**

This test measures the response times of the analyzer or sensor itself, without the influence of the sample system.

a) Connect a strip chart recorder or data acquisition system (DAS) to the analyzer/sensor output(s). See §5.2(d).

b) Zero and gas-calibrate the candidate per the manufacturer's instructions.

c) Install a flowmeter just upstream of the analyzer/sensor inlet port. Note that some configurations have the NO sensor in a bypass stream around the NDIR bench. In this case, install the flowmeter upstream of the bypass branch.

d) With the sampling system in the exhaust-sampling mode, measure and record the flow rate to the analyzer/sensor.

e) Connect a cylinder of High Range BAR-97 calibration gas with pressure regulator, needle valve and 3-way solenoid valve or other switching means, to the inlet of the flowmeter. (The sample system is thus disconnected.) Connect a cylinder of zero gas (nitrogen or zero air) with pressure regulator and needle valve to the other port of the solenoid valve.

f) Adjust gas flow from each cylinder to the analyzer/sensor so that their flow rates match that recorded in Step (c).

g) With the recorder or DAS running, feed zero gas to the analyzer/sensor for 60 seconds.

h) Switch the solenoid valve so that calibration gas flows to the analyzer/sensor for 60 seconds.

i) Repeat Steps (g) and (h) two more times, and then Step (g) once more.

Acceptance Criteria: Rising and falling response times shall meet the requirements of Section 2.4.5 r.

5.4.12 **Ambient Temperature Noise Tests**

The following tests examine the sensitivity of the candidate units to extraneous electrical and electromagnetic inputs.

a) **Automotive RFI Test**

1. Use a test vehicle with an engine having a high-energy ignition system or equivalent, a solid core coil wire and a 3/8" air gap. Leave the engine off.

2. Locate the EIS within 5 feet of the front of the vehicle. Gas-calibrate the unit.

3. Sample BAR-97 Low Range calibration gas through the probe. Gas pressure shall be room ambient atmospheric (zero psig) at the entrance to the probe. Record the readings.

4. Start the engine. With the hood open, cycle the engine from idle through 2500 RPM. With the Low Range gas flowing through the probe, record the readings.

5. Relocate the unit to within 6 inches of one side of the engine compartment and repeat the test in Step 4.

6. Relocate the unit to within 6 inches of the other side of the engine compartment and repeat the test in Step 4.

Acceptance Criteria: The readings shall deviate no more than 1/3 of the accuracy requirements in §2.4.5.j), or one least significant digit, whichever is greater.

b) **Induction Field Test**

Use a variable speed (commutator type) hand drill having a plastic housing and rated at 3 amps or more. While sampling BAR-97 Low Range calibration gas, vary the drill speed from zero to maximum while moving from the front to the sides of the unit at various heights.

Acceptance Criteria: The readings shall deviate no more than 1/3 of the accuracy requirements in §2.4.5.j).

c) **Line Interference Test**

Plug the variable speed drill described in subsection b) into one of the two outlets of a #16-3 wire extension cord 20 feet long. Connect the unit into the other outlet of the extension cord. Repeat subsection b) above.

Acceptance Criteria: The readings shall deviate no more than 1/3 of the accuracy requirements in §2.4.5.j), or one least significant digit, whichever is greater.

d) **VHF Band Frequency Interference Test**

While sampling BAR-97 Low Range calibration gas, press and release the transmit button of a citizens band radio transmitter (with output equivalent to FCC legal maximum), and simultaneously key a highway patrol transmitter (or equivalent). Both transmitters shall be located within 50 feet of the analyzer.

Acceptance Criteria: The readings shall deviate no more than 1/3 of the accuracy requirements in §2.4.5.j), or one least significant digit, whichever is greater.

5.4.13 **Vibration and Shock — Ambient Temperature Only**

The vibration test simulates rolling a mobile unit over a rough garage floor. The shock test simulates a rolling EIS which collides with a wall or other fixed object. (This test does not require temperature conditioning.)

The test floor shall be a 6' x 10' expanded metal grating with diamond-shaped openings of 1 x 3.7" or equivalent, elevated 2" off the test facility floor.

a) Zero and calibrate the unit in accordance with the EIS manufacturer's instructions. Introduce BAR-97 Low Range calibration gas to the probe (pressure = zero psig); record the readings.

b) Roll the unit six times over the 6' x 10' expanded metal grating in the direction of the "short way of the diamond." Roll the unit completely off the edge of the grating each time.

c) Introduce the Low Range calibration gas to the probe (pressure = zero psig); record the readings.

Acceptance Criteria: The EIS readings shall not have permanently shifted more than the accuracy requirements in §2.4.5.j) from the original zero and span check values.

5.5 CERTIFICATION TEST PROCEDURES: ANALYZER/SAMPLE SYSTEM INTEGRATION

5.5.1 **System Repeatability *and Calibration/Sample Path Balance***

This test characterizes the ability of the EIS to give consistent readings when repeatedly sampling the same gas concentration.

a) Introduce BAR-97 Low Range calibration gas through the calibration port. Record the readings.

b) Purge with ambient air or zero air for a minimum of 30 seconds and a maximum of one minute.

c) Repeat Steps (a) and (b) four more times.

d) Repeat Steps (a), (b) and (c), introducing the gas through the probe.

NOTE: If only one path exists through the analyzer, perform Steps (a) and (b) ten times.

Acceptance Criteria: The difference between the highest and the lowest readings from the data for both the calibration port and probe combined shall not exceed the Repeatability requirements of §2.4.5.k).

e) Average the five sets of readings taken in Steps a) through c), above. In other words, take the average of the five HC readings, the five CO readings, etc.

f) Average the five sets of readings taken in Step d), above.

g) Determine the relative difference between the HC, CO, CO_2, and/or NO averages in Step e) and those in Step f); e.g.,
Relative Difference for HC, %, = 100 x [$(f_{avg} - e_{avg})/e_{avg}]_{HC}$

Acceptance Criteria: *None of the relative differences calculated in Step g) above shall exceed ±1% or 1 least significant digit, whichever is greater.*

5.5.2 **System Response Time**

This test determines the speed of response of the candidate units to the introduction of a gas through its probe when their sample systems are clean.

a) Connect a strip chart recorder or data acquisition system (DAS) to the EIS output(s). See §5.2 (d)

b) Zero and gas-calibrate the candidate per the manufacturer's instructions.

c) A 3-way solenoid valve or equivalent selector system (or alternate BAR-approved method), shall be used to alternately introduce zero air (or nitrogen) and BAR-97 High Range calibration gas to the probe. The gas pressure at the entrance to the probe shall be equal to room ambient (i.e., zero psig). A balloon teed into the gas line just ahead of the probe may be used to adjust the pressure at the probe tip for each gas. The balloon, with the sample pump running, shall stand erect but shall not be inflated.

d) With the recorder or DAS running, feed zero gas to the EIS for 60 seconds.

e) Switch the solenoid valve so that the High Range calibration gas flows to the EIS for 60 seconds.

f) Repeat Steps (d) and (e) two more times, and then Step (d) once more.

Acceptance Criteria: Response times for each channel shall meet the requirements of §2.4.6 g).

5.6 CERTIFICATION TEST PROCEDURES: DYNAMOMETER, CONTROLS & INTERFACING

At the time of dynamometer certification, each dynamometer manufacturer shall submit data demonstrating the dynamometer's ability to meet BAR-97 specifications. This data shall include, as a minimum, verification of the following tests.

To aid in the testing of the dynamometers at BAR, the dynamometer must be accompanied by software capable of:

1. Performing steady state tests at different loads
2. Coast downs at different load settings (30 to 15 mph) according to the BAR-97 specification
3. Performing specialized coast down algorithm in accordance with §5.6.5.
4. Performing BAR-31 simulation given different load coefficients
5. Parasitic loss determination according to the BAR-97 specification
6. Conducting a free form drive trace given different load coefficients

Once the dynamometer has been submitted for testing, BAR will spot check the manufacturer's generated test results for accuracy. In addition, BAR will also perform additional testing to ensure compliance with the BAR-97 specification.

5.6.1 Base Inertia Determination

The dynamometer manufacturer shall demonstrate their method for base inertia determination and submit test results verifying that the base inertia of the dynamometer is within BAR-97 specifications. The determination method is subject to BAR approval.

Acceptance Criteria: Base inertia shall be 2000 ±40 lbs. The base inertia quantified on the dynamometer ID plate matches the measured base inertia within ±10 lbs.

5.6.2 Speed Accuracy Determination

The dynamometer manufacturer shall demonstrate their method for speed accuracy determination and submit test results verifying that the speed measurement of the dynamometer is within BAR-97 specifications. The determination method is subject to BAR approval.

Acceptance Criteria: Speed shall be accurate to within 0.1 mph.

5.6.3 Load Accuracy

As a minimum, 12 tests must be conducted to demonstrate load accuracy under varying conditions as provided in the Load Accuracy Test Condition Matrix (i.e., test 6 requires a calibration temperature and test ambient temperature of 75F with nominal calibration voltage and high test supply voltage in a maximum warm-up condition and a 15 hp load).

Changes that might affect the accuracy of the system may not be made in between these tests. If a change must be made, the testing shall start over.

In each case, the dynamometer must soak for at least eight hours in the appropriate temperature before conducting either calibration or testing. For both calibration and testing, the dynamometer shall be warmed-up according to the manufacturer's requirements. If no warm-up is required, none will be allowed.

After waiting the required amount of time (see warm-up time), coast down checks, from 30.0 mph to 15.0 mph according to the BAR-97 procedures, shall be performed according to the conditions listed for each of the 12 tests in the matrix. In each case, for acceptance testing purposes, the time from when the rolls start turning until the dynamometer begins coasting shall not exceed 30 seconds. An external means may be used to bring the dynamometer up to speed in the required time as long as it can be disengaged during the coast down.

The dynamometer shall use any applicable temperature correction or similar algorithms during the coast downs that would be used normally during an ASM test.

Each of the load accuracy tests will be followed by the Response Time Tests and the Variable Load Coast-Down Tests, which will be conducted under the same conditions.

Load Accuracy Test Condition Matrix

		Test Number											
Condition		1	2	3	4	5	6	7	8	9	10	11	12
Calibration	110 F									x	x	x	x
Temp	75 F					x	x	x	x				
	35 F	x	x	x	x								
Test	110 F	x	x	x	x								
Ambient	75 F					x	x	x	x				
Temp	35 F									x	x	x	x
Calibration	High	x	x									x	x
Voltage	Nominal					x	x	x	x				
	Low			x	x					x	x		
Test	High			x	x	x	x						
Supply	Nominal									x	x	x	x
Voltage	Low	x	x					x	x				
Warm Up	Maximum		x		x		x		x		x		x
	Minimum	x		x		x		x		x		x	

Load	25 hp		x	x						x			x
	15 hp					x	x	x	x				
	5 hp	x			x						x	x	

Definition of Terms:

Calibration Temp is the temperature at which to calibrate the equipment. Prior to conducting the calibration, the equipment must soak for at least eight hours at the calibration temperature so that the dynamometer is in thermal equilibrium with its environment.

Test Ambient Temp is the temperature at which to conduct the test. Prior to conducting this test (and after calibration), the equipment must soak for at least eight hours in the ambient temperature to achieve thermal equilibrium.

Calibration Voltage is the supply voltage powering the equipment during calibration expressed as a percentage of nominal required voltage, as follows:

Possible nominal voltages (volts AC):	115	230	460
Corresponding high voltages (volts AC):	127	254	508
Corresponding low voltages (volts AC):	103	206	412

Test Supply Voltage is the supply voltage powering the equipment during the test expressed as a percentage of nominal required voltage. See Calibration Voltage for definition of high, nominal, and low voltages.

Warm-Up The maximum warm-up condition occurs after the dynamometer completes any required warm-up immediately prior to completing the test (not calibration). The minimum warm-up condition occurs when the dynamometer rests for the maximum amount of time allowable by the manufacturer between tests without performing a dynamometer warm-up. During this wait time, the dynamometer shall be soaked at the required test ambient temperature. If no warm-up is required, this time will be assumed to be two hours.

Load is the horsepower that the dynamometer should be applying during the coast down test.

> **Acceptance Criteria:** Coast down times must be within 4% of the nominal time for the 5 hp and 25 hp coast downs, and within 2% of the nominal time for the 15 hp setting. Nominal values for the coast down times can be calculated from the equation in §2.5.7.2 of the BAR-97 specifications.

5.6.4 **Response Time**

After conducting each of the load accuracy tests, the following response time tests must be conducted, which will then be followed by the variable load coast down test.

1. The dynamometer rolls should be spinning at a speed of approximately 40 mph with no force being applied by the PAU.
2. A torque equivalent to [b]* horsepower at [a]* mph should be applied by the PAU when the dynamometer speed reaches 35 mph.
3. When the speed reaches [a]* miles per hour, apply a command torque to the PAU Controller equal to [c]* horsepower at that speed.
4. Record the start time as the time when the command torque (step 3) is sent to the PAU Controller.
5. Monitor and record the actual PAU load sensing device output signal.
6. When the output reaches 90% of the command torque (step 3), the time shall be recorded as the response time.
7. When the output reaches its peak overshoot (if any) above the command torque (step 3), this value shall be recorded as the overshoot.
8. The mean settling time shall be recorded when the following conditions are met.
   a. The mean torque output averaged over 300 milliseconds settles within either ±2% of the command load or 0.25 horsepower at [a]* mph.
   b. The instantaneous horsepower falls within 5% of the command load during the entire 300 ms that the average is being calculated.

* refers to the variables listed in the chart below.

	Test Number							
Variable	1	2	3	4	5	6	7	8
a. Speed (mph)	10	10	15	15	25	25	30	30
b. Initial Load (hp)	4	10	16	22	20	26	6	16
c. Final Load (hp)	10	4	22	16	26	20	16	6

Acceptance Criteria: The dynamometer must respond to 90% of a torque step change within 300 milliseconds. The mean settling time must be less than 600 milliseconds from the initiation of the step change.

5.6.5 **Power Absorber Range**

The dynamometer manufacturer shall demonstrate their method for power absorber's range determination and submit test results verifying that the response time measurement of the dynamometer is within BAR-97 specifications. The determination method is subject to BAR approval.

Acceptance Criteria: The power absorber shall be able to absorb, at 14 mph 0.3 mph, a minimum of 25 hp ±0.25 hp or 2.0%, whichever is greater, continuously both at the beginning and at the end of the test. The absorber shall meet this

specification for a steady-state test lasting at least five minutes, with three minutes between tests for a total of 10 cycles.

5.6.6 **Augmented Braking**

The dynamometer manufacturer shall demonstrate that augmented braking is applied at the conclusion of the 2525 mode of the ASM test. The determination method is subject to BAR approval.

5.6.7 **Speed Synchronization** (4wd dynamometers and/or dynamometers with split rolls that are not rigidly connected)

The dynamometer manufacturer shall demonstrate their method for roll speed synchronization determination and submit test results verifying that the speed synchronization is within BAR-97 specifications. The determination method is subject to BAR approval.

Acceptance Criteria: Front and rear-wheel or side-to-side rolls shall maintain speed synchronization of ± 0.2 mph.

5.6.8 **RFI Noise Test**

The dynamometer manufacturer shall demonstrate their method for determining the system's noise resistance and submit test results verifying that the interference noise resistance is within BAR-97 specifications. The determination method is subject to BAR approval.

Acceptance Criteria: The values read by the dynamometer tester shall be within 0.5 hp of the target value within 15 seconds of reaching the target speed, and within 0.25 hp within 30 seconds of reaching the target speed. In addition, there must be no detectable glitches resulting from the presence of the RFI noise, up to 3000-rpm engine speed.

5.6.9 **Variable Load Coast Down**

The following procedure shall be followed to verify the system's ability to apply variable loading accurately in spite of response time differences that may exist between a positive step torque change and a negative step torque change.

1. Spin the dynamometer rolls up to 55 mph.
2. Load the dynamometer to 5 hp.
3. When the dynamometer speed reaches 50 mph, record the start time.
4. According to the following chart, load the dynamometer appropriately for each speed shown. At each increment, the load shall be applied in step increments (i.e., the load for a speed less than or equal to 50 mph and greater than 49 shall be 5 hp).
5. Record the times at each speed.

The time it takes to perform this operation will be predictable when the exact dynamometer inertia is known. Variances from the nominal time may be accounted for with load inaccuracies, response time problems, etc. For a dynamometer with 2000 pounds of base inertia, the nominal time for the dynamometer to coast from 50 mph to 5 mph is 25.31 seconds given the following scenario.

SPEED	HP LOAD
50	5
49	6
48	7
47	8
46	9
45	10
44	8
43	10
42	12
41	14
40	16
39	18
38	20
37	21
36	22
35	23

SPEED	HP LOAD
34	24
33	25
32	24
31	23
30	22
29	21
28	20
27	18
26	16
25	14
24	15
23	16
22	17
21	18
20	17

SPEED	HP LOAD
19	16
18	15
17	14
16	12
15	10
14	11
13	12
12	11
11	10
10	9
9	8
8	7
7	6
6	5
5	5

Acceptance Criteria: The time it takes the dynamometer to decelerate through the above steps must fall within the following tolerances.

Initial Speed	**Final Speed**	**Nominal Time**	**Tolerance**
50.00	5.00	25.31	4.00%
45.00	10.00	15.35	2.00%
38.00	27.00	3.92	3.00%

5.7 CERTIFICATION TEST PROCEDURES: THROUGHPUT CAPACITY

The emissions analyzer/sampling system shall be designed so that it is capable of performing at least 10 tests per hour for eight consecutive hours without experiencing excessive hangup or other deleterious effects. A study shall be submitted to the BAR

indicating the maximum number of tests per hour that were achieved using the analyzer submitted for certification. A brief description of the study methodology used by the manufacturer to make the throughput determination shall be included in the study. This evaluation shall not include the time required to enter vehicle identification data or to conduct the visual and/or functional inspections.

5.8 CERTIFICATION TEST PROCEDURES: AUXILIARY TEST EQUIPMENT

5.8.1 Certification Test Procedures for Standard Tachometer & Connection (1995 and Earlier Model Year Vehicles)

The following test shall be performed on each of the following engines as a minimum: conventional ignition, Quad 4, Nissan Pulsar, rotary engine with DIS Distributorless Ignition System (DIS), and C3I.

a) Connect the candidate unit's RPM sensor to a test vehicle's engine (an engine on a test stand may be substituted).

b) Place a piece of reflective foil suitable for use with an optical tachometer on an appropriate rotating engine component whose ratio of rotation with respect to engine RPM is known.

c) With the engine warmed up and at idle RPM, measure the engine speed using the candidate's tachometer and also using an optical tachometer having an accuracy of 1 rpm. Record the readings.

d) Repeat Step c) at engine speeds of 1500, 2000, 2500, 3000, 2500, 2000, 1500 (all +/-50 RPM), and idle RPM.

e) For each engine speed, calculate the differences between each candidate reading and its paired optical tachometer reading.

Acceptance Criteria: For each engine speed, no difference shall be greater than +/-3% of the nominal engine speed being measured.

5.8.2 Certification Test Procedure for OBDII Tachometer & Connection (1996 and Later Model Year Vehicles)

Manufacturers must provide complete test results (OBDII rpm readings compared to optical tachometer) showing the functionality of the OBDII diagnostic test connector for the following vehicles:

a) Four domestic vehicles from different manufacturers and engine types.
b) Two vehicles manufactured in Japan. Both vehicles must be from different manufacturers and different engine types. The vehicles must not be under a domestic manufacturer's name.

c) One vehicle manufactured in Europe (not under a domestic manufacturer's name).

Acceptance Criteria: For each engine speed, no difference shall be greater than +/-3% of the nominal engine speed being measured.

5.8.3 **Bar Code Scanner**

Manufacturers seeking BAR certification for their bar code scanner must specify the model name and serial number of the scanner they intend to use with their EIS. The specified bar code scanner must be compatible with at least two different off-the-shelf bar code scanners from different manufacturers (including all required cabling and power supplies) and capable of reading VIN, etc. Once the specified bar code scanner has been accepted, information about the scanner will be non-proprietary and BAR will release such information to all EIS owners.

For the purpose of certification, BAR will obtain off-the-shelf scanners and perform acceptance tests on them (rather than accept submission by the manufacturer).

Each of the following bar code scanner reading tests shall be performed five times by scanning the bar code and clearing the reading from the EIS before each attempt:

a) Bar code is on a sticker located about one inch behind a windshield.

b) Bar code is etched through a white painted area on a standard black metal VIN plate.

c) Bar code is on the domed section of a disposable calibration gas cylinder.

Acceptance Criteria: The scanner must demonstrate its ability to reliably read all configurations by successfully reading the code on all ten attempts.

5.8.4 **Fuel Cap Tester**

a) **Accuracy**

(NOTE: This test may be performed as part of the Temperature test (see (b), below.)

1. Calibrate the candidate fuel cap tester with the manufacturer-provided "Pass/Fail Master" cap set. The candidate fuel cap tester shall pass this calibration check.

   i. The "Master Pass" calibration cap shall be flow tested. Attach a flowmeter (such as a Sierra Toptrack Series 800) and an adjustment device to the cap and adjust the pressure to 30" of H_2O. Measure the flow with the attached flowmeter and record the flow rate. The "Master Pass" cap shall not be less than 52cc nor more than 56cc.

   ii. The "Master Fail" calibration cap shall be flow tested. Attach a flowmeter/adjustment device to the cap and adjust the pressure to 30" of H_2O. Measure the flow with the attached flowmeter and record the flow rate. The "Master Fail" cap shall not be less than 64cc nor more than 68cc.

2. Attach the flowmeter/adjustment device to the candidate tester, and adjust the leakage flow to between 52 and 56 cc/min.

3. Release the pressure; then repressurize to start the test.

4. Record the tester's pass/fail determination.

5. Repeat (3) and (4) four times, each time noting the leakage flow to ensure that it has not drifted out of the set range.

6. Pressurize the tester and adjust the leakage flow to between 64 and 68 cc/min.

7. Repeat steps (3), (4), and (5) for the new leakage flow setting.

   Acceptance Criteria: (1) For steps 4) and 5), the tester's pass/fail determination shall be "Pass" for all five runs. (2) for step 7), the tester's pass/fail determination shall be "Fail" for all five runs.

b) **Temperature**

Temperature testing shall be performed in an environmental chamber at the same time as the analyzer is undergoing the Temperature Stability Test (see §5.4.2).

1. At 75°F, perform the complete accuracy test (see (a), above).

2. At 50°F and 100°F, perform steps 2) through 7) of a) above. DO NOT RECALIBRATE.

Acceptance Criteria: For each temperature, same criteria as those of the accuracy test (see (a) above).

c) **Altitude**

1. Calibrate the candidate fuel cap tester with the manufacturer-provided "Pass/Fail Master" cap set.

2. Attach a gauge/valve/reservoir/pump arrangement (similar to that attached to the analyzer's sample cell exhaust during pressure compensation testing, §5.4.10) to the outlet of the flowmeter/adjustment device.

3. Evacuate the entire fuel tester system to 24" HgA. Allow the tester's pressurization system to pressurize to 30" H_2O gauge (i.e., 30" H_2O above 24" HgA).

4. Adjust the flow to between 52 and 56 cc/min.

Acceptance Criteria: The tester shall indicate a "Pass."

5. Adjust the flow to between 64 and 68 cc/min.

Acceptance Criteria: The tester shall indicate a "Pass."

5.8.5 **Fan Testing**

The fan flow testing shall be done using an air velocity meter. Readings shall be taken at the fan shroud exhaust surface, from the center to the edge of the shroud in 1inch increments. The velocity of the exhaust air shall be summed over the area of the fan to determine the volumetric flow rate in cfm of the fan.

Acceptance Criteria: The fan shall have a maximum outer diameter of 30 inches and must deliver at least 3000 cfm or at least 10mph air velocity averaged over the cross section of the fan, whichever is greater. See section 2.5.8.8.

5.8.6 Zero Air Generators

1. **SCOPE**

BAR performs the following tests to determine if a zero air generator is BAR-97 compliant. The tests apply regardless of whether the generators are mounted internally or externally to an Emissions Inspection System (EIS) cabinet. The acceptance criteria may, however, be reinterpreted for internally- vs. externally-mounted generators. For example, the term "visual indication" may be interpreted as a lit lamp on an external unit and as a prompt on the EIS display for an internal unit. Performance criteria are identical between the two types of zero air generators.

Note: Zero Air generators shall have a BAR registered manufacturers part number visible for field inspection and verification. See section 2.12.

2. **TESTING & METHODOLOGY**

a. <u>Tests To Be Performed</u>

i. Warmup at 35°F & 110°F Ambient: To determine that the zero air generator…

1) warms up in 30 minutes or less;
2) delivers no air during warmup;
3) delivers air of the required purity after exiting its warmup mode when challenged with supply air at the specified limits of contamination;
4) provides a visual indication that the unit is warming up.

ii. Outlet (Delivered) Air Purity at 35°F & 110°F Ambient: To determine that the generator delivers air of the required purity over a continuous two-hour period when challenged with supply air at the specified limits of contamination.

iii. Response to Abnormal Conditions (Any Temperature): The generator must deliver no zero air, and must provide a visual indication when the following conditions are present:

1) Warmup Mode
2) Low supply pressure
3) Low catalyst temperature
4) Pressure swing system fault (e.g., solenoid valve failure)

b. <u>Test Methodology</u>

i. Equipment:

1) Equitherm Environmental Room, 8' x 8' x 8'.
2) HC Analyzer: FID, Horiba Model FIA-220
3) CO Analyzer: NDIR, Horiba Model APMA-360
4) NO Analyzer: Chemiluminescent, Horiba Model CLA-220
5) CO_2 Analyzer, NDIR, Horiba Model APBA-210

6) Data Acquisition Unit (DAU) & software, Strawberry Tree DATAshuttle
7) Zero Air
8) Nitrogen (N_2)
9) Challenge Gas: 100 ppm CH_3, 100 ppm CO, 1500 ppm CO_2, Balance: Air
10) Challenge Gas: 100 ppm NO, Balance: N_2
11) Compressed air supply
12) Flowmeters, valves, fittings, pressure gauges, no-outgassing hose, adapters

ii. Warmup Test Procedure

NOTE: Due to the delivery flow rate limitations of some ZAGs and the needs and characteristics of the analyzers, the warmup testing must be done in three stages: once for HC, once for NO, and once for CO and CO_2. The is because the analyzers cannot be connected in series — the CO & CO_2 analyzers have pumps, the others don't, and only the CO_2 analyzer doesn't change the gas in some way during measurement — and because the NO must be in a separate cylinder from the other gases to avoid interaction with air.

1) Set environmental room (ER) temperature to 35°F
2) Place zero air generator in ER with power OFF.
3) After the ER has reached 35°F, let the generator stabilize for an additional 1½ hours with the power off.
4) Start DAU logging (record date/time and analyzer outputs at 0.25 Hz sampling rate).
5) Analyzers have been powered up for 24 hours. Zero and calibrate those to be used (see note above), using the DAU's laptop display for adjustments.
6) Connect the outlet port of the generator through a needle valve and flowmeter to the analyzer.
7) Connect the challenge gas directly to the supply air inlet of the zero air generator, open the cylinder and regulator shutoff valves, and set the cylinder outlet pressure to 100 psig..
   a) *NOTE: For NO, the challenge gas must be diluted with an equal part of air to bring it down to the specified value of 50 ppm, since the generator needs air to function.* Connect the challenge gas regulator output to a flowmeter, then to one branch of a tee fitting. Connect a similarly-equipped zero air cylinder to a second branch of the tee. Connect the third branch of the tee to the fully-closed needle valve (see (6) above) going to the NO analyzer sample input.
   b) With both cylinder regulators set to provide 100 psig, gradually open the needle valve until the NO analyzer is receiving 1.5 – 2 Lpm. Adjust the zero air cylinder's regulator until the analyzer reads 50 ppm NO.
   c) Close the zero air and challenge gas cylinder valves *without touching the regulator controls.* Let trapped gas bleed out through the analyzer.
   d) Disconnect from the needle valve at the analyzer sample inlet, and connect to the supply air inlet of the generator using an appropriate quick-connect adapter. Open the cylinder shutoff valves simultaneously, or, if this is not possible, open the challenge gas cylinder first.

e) Reconnect the generator output to the analyzer.

8) Turn on the power to the generator. Note the time. (A stopwatch may be used.)
   a) Verify that the generator gives a visual indication that it is in the warmup mode.
   b) Check the flowmeter to the analyzer to verify that the generator is delivering no flow.
9) Note the time at which the generator completes warmup (the visual indication turns off; the generator starts delivering flow.)
10) Verify (from the DAU real-time display) that the analyzer readings are less than or equal to the required values (≤1 ppm THC, CO, NO; ≤200 ppm CO_2).
11) With the DAU still logging, shut off the challenge gas(es), let the pressure bleed down, and note the pressure at which the "Low Supply Pressure" visual indication is activated, and verify that the generator's outlet flow is stopped.
12) Close the regulator(s) shutoff valve, disconnect from the generator's supply air inlet, and connect the compressed air supply in its place. Verify that the fault indication is deactivated and that outlet flow resumes.
13) Disconnect the generator outlet from the analyzer, then flow zero gas (zero air or N_2 to the analyzer, followed by calibration gas, to check the analyzer's drift..
14) Reconnect the generator's outlet to the analyzer to clean it out. Stop the DAU's logging.

Acceptance Criteria: (a) The generator shall give a visual indication that it is in the warmup mode. (b) The generator shall deliver no flow during warmup. (c) The generator shall exit the warmup mode in 30 minutes or less. (d) At completion of the warmup mode, the "Warmup" indication shall be deactivated and a "Normal Operation" indication shall be activated. (e) The analyzer readings are less than or equal to the required values (≤1 ppm THC, CO, NO; ≤200 ppm CO_2).

iii. **Outlet Air Purity**

1) Setup is the same as for Warmup testing, except the test is performed on a fully warmed-up generator. *Note that this test should be performed as a continuation of the Warmup test.*
2) With the challenge gas entering the generator's supply air inlet, the generator outlet connected as above to the analyzer(s), and the DAU logging, monitor the generator's output air purity for two hours.
3) Perform Steps (10) through (14) of the Warmup test, as applicable.

Acceptance Criteria: At the end of the two hours, The analyzer readings shall be less than or equal to the required values (≤1 ppm THC, CO, NO; ≤200 ppm CO_2).

iv. Response to Abnormal Conditions

1) Low Supply Pressure: See ii 11) and 12).

2) Low Catalyst Temperature: Disconnect the power to the catalyst while the unit is operating. Verify that outlet flow is shut off and a visual indication is activated when the catalyst temperature falls below the manufacturer's set threshold.

3) Pressure Swing Fault: Disconnect power to the pressure swing solenoid valve. Alternatively, disconnect the tubing to the pressure sensor (if used) that monitors the switching action. Verify that outlet flow is shut off and a visual indication is activated when a column switchover does not take place in double the manufacturer's switching interval.

Acceptance Criteria: (a) If supply pressure to the generator falls below the manufacturer's set threshold, (i) a "Low Supply Pressure" indication shall be activated, and (ii) generator output flow shall be interrupted. (b) Upon restoration of supply pressure, (i) the "Low Supply Pressure" indication shall be deactivated, and (ii) generator output flow shall be restored. (c) When the catalyst temperature falls below the manufacturer's set threshold, (i) an indication shall be activated and (ii) outlet flow shall be shut off. (d) When the catalyst temperature rises above the manufacturer's set threshold, (i) the indication shall be deactivated and (ii) outlet flow shall be restored.

v. Transfer all data to the appropriate blank data sheets

5.8.7 **Ambient Relative Humidity, Temperature & Barometric Pressure Sensors** (Ref: §2.4.11, 2.4.12, 2.4.13)

a) During each condition of the Temperature Stability Test (§5.4.2), and during each condition of the Accuracy & Bias Test (§5.4.6), the readings from these sensors shall be compared to the readings from standard instruments.

Acceptance Criteria: (1) The temperature readings shall differ by no more than 6^{o}F at any ambient condition. (2) The relative humidity readings shall differ by no more than 6% RH at any ambient condition. (3) The barometric pressure readings shall differ by no more than 0.40 inches Hg at any ambient condition.

b) During Pressure Compensation testing for the O_2 cells, the readings from the barometric pressure sensor shall be compared to the readings from a standard instrument.

Acceptance Criteria: The barometric pressure readings shall differ by no more than 0.40 inches Hg at any ambient condition.

5.9 **CERTIFICATION TEST PROCEDURES: COMPUTER AND PERIPHERALS**

5.9.1 **Compatibility**

Computers offered must be able to reliably read and write floppy disks for use with existing IBM PC-compatible 1.44Mb 3.5" diskettes and disk format.

Systems must be able to interchange/use software and data files with existing State-owned IBM-PC compatible models without requiring software or hardware reconfiguration.

Systems must be capable of producing graphic output on CRT displays and dot matrix printers. Use of 'PrintScreen' key must cause text displayed on CRT to print on printer.

5.9.2 **Hard Disk**

This test exercises the hard disk under high-temperature, high-humidity conditions to ensure that it will function consistently in an adverse environment. THE TEST SHALL BE PERFORMED AT THE 105^{o}F (5^{o}F), 80% (5%) R.H. CONDITION ONLY.

A sequence of read/write operations shall be performed under the automatic control of the latest version of either Norton Utilities' Disktest (DT) and System Information (SI) programs, or PC Magazine Laboratory's Benchmark Series Hardware Performance Tests.

5.9.3 **Modem**

The modem must meet the criteria specified in Sections 2 and 3.

5.10 **CERTIFICATION TEST PROCEDURES: SOFTWARE & COMMUNICATIONS**

The manufacturer shall perform software verification before submittal of the EIS units for certification testing. Certification testing will be conducted at BAR Headquarters in Sacramento, California. The manufacturer is required to provide and set up the entire proposed configuration, based on BAR-provided specifications and protocols. The BAR will test all critical areas to ensure that the proper logic is followed, the proper decisions made, the correct screen data is displayed and the correct printing formatting has been implemented. Simulated and actual inspection tests will be performed to determine that they are properly and completely performed. Test and calibration records will be examined to verify that all the fields are properly formatted and filled, and that the records are accurate and complete. Testing will be performed to verify the ability of the EIS to dial up and connect with the BAR Vehicle Information Database (VID) and to transfer and receive files, data, messages, etc. to and from the VID. Other tests will be made on an ad hoc basis to attempt to uncover flaws in the software, procedures and security, and that recovery from operator errors is benign.

As an aid to software certification testing, analyzer and dynamometer simulators shall be provided, as described below.

a) **Gas Analyzer Simulator**

The simulator may be either hardware, software or both. It must be capable of performing the following simulated functions as a minimum. The functions shall be selectable in any combination:

1. Warmup - Simulate the gas analyzer warming up in about two minutes. Simulate the analyzer failing warmup.

2. Zero - Simulate zeroing after warmup and on demand (see §2.4.5.a). Simulate the analyzer failing zero.

3. Sample Dilution - Simulate CO + CO_2 readings allowing a test to proceed. Simulate CO + CO_2 readings that will elicit a "Sample Dilution" message.

4. "Pass" Readings - Simulate passing readings for HC, CO & NO.

5. "Fail" Readings - Simulate failing readings for HC only, CO only, NO only, HC & CO, HC & NO, CO & NO, and HC, CO & NO. Failing readings shall be appropriate to the cutpoints for the simulated vehicle under test.

6. "Gross Polluter" Readings - Simulate Gross Polluter readings for HC only, CO only, NO only, HC & CO, HC & NO, CO & NO, and HC, CO & NO. Readings shall be appropriate to the Gross Polluter cutpoints for the simulated vehicle under test.

   [Note: As an alternative, the individual channels may be individually adjustable over their full concentration ranges.]

7. Gas Calibration - Simulate the analyzer's responses to the Gas Calibration, Leak Check, and Three-day Gas Calibration/Leak Check modes. The 3-day calibration mode shall include a simulation of the response time checks. (See §3.9) The simulator shall be capable of passing and failing the calibration, response time, and/or leak check modes.

8. HC Hangup Checks - simulate a passing check and a failing check.

b) **Dynamometer Simulator**

The dynamometer simulation software shall be able to simulate the following:

- Coast down pass and fail
- Parasitic loss pass and fail during calibration
- Load cell pass and fail during calibration
- Loading error during test mode
- Restraints on or off
- Lift up - not responding to the given signal
- Lift down - not responding to the given signal
- Speed ramps of selectable constant acceleration rate from 0 to 15 mph
- Speed ramps of selectable constant acceleration rate from 15 to 25 mph

- Speed ramps of selectable constant deceleration rates from 25 to 0 mph
- Simulate selectable speeds
- Read and respond to (feedback) command load sent to the dynamometer
- Axle weight measuring device - simulate any weight selected by the test operator
- If dynamometer is 4wd and will have automatic engagement of the auxiliary rolls, the simulator must be able to simulate the condition where the auxiliary rolls fail to engage or fail to disengage.

Driver Simulation

In addition to the above, the simulator must also be able to simulate the following mode situations. These mode situations will start at the end of the appropriate ramp as selected above and end with the next appropriate ramp. These situations must be applied to both the 5015 portion of the test and the 2525 portion of the test. These situations shall be able to be employed in conjunction with the above ramps to make a seamless drive trace. Modes may be terminated early as selected by the operator to allow for circumstances where the EIS software passes a vehicle prior to the completion of the maximum mode length.

Traces to Simulate

1. Excessive Number of Acceleration Violations. The software shall simulate 6 acceleration violation events having a cumulative violation time of 5 seconds. These events must occur no earlier than 11 seconds after the emissions averaging portion of the test has begun, though other acceleration violations shall occur before 11 seconds. Violations shall be grouped in such a way as not to prevent 25 valid 10 second averages from being collected. (Software should restart test mode for excessive number of acceleration violations - §3.6.11.d & e)

2. Excessive Acceleration Violation Cumulative Time. The software shall simulate 5 acceleration violation events having a cumulative violation time of 6 seconds. These events must occur no earlier than 11 seconds after the emissions averaging portion of the test has begun, though other acceleration violations shall occur before 11 seconds. Violations shall be grouped in such a way as not to prevent 25 valid 10 second averages from being collected. (Software should stop test mode for excessive acceleration violation cumulative time - §3.6.11.d & e)

3. Allowable Driver Speed Violations. The software shall simulate driver speed violations (speed deviates by more than 1 mph from target speed, i.e., 15 or 25 mph) lasting 5 seconds. There shall be 3 occurrences per test mode. (Software should permit speed violations of this length - §3.6.11.d & e)

4. Illegal driver speed violations. The software shall simulate a driver speed violation lasting 6 seconds. (Software should stop test mode for excessively long speed violation - §3.6.11.d & e)

5. Inadequate Number of Valid 10-Second Averages. The software shall simulate the situations where 25 valid 10-second averages could not being taken due to acceleration violation errors rendering the average invalid. This may not be possible in both modes (i.e., with a fast enough response time, this may not be possible in the 5015 mode without failing the acceleration criteria first). (Software should require restart - §3.6.11.h.1.vi)

6. Driver error-free tests. Normal ASM drive trace without errors or excursions.

5.11 CERTIFICATION TEST PROCEDURES: SYSTEM INTEGRATION

The EIS shall be tested as an integrated system, as follows, using the BAR dynamometer tester as the "test vehicle."

a) Precision gases simulating true vehicle exhaust shall be used.

b) Six ASM tests shall be run as a minimum:

1. At least two tests with final result "pass,"

2. At least two tests with final result "fail" (marginal fail),

3. At least two tests with final result "fail" (gross polluter).

[Note: The gas blends used for testing will contain HC, CO, CO_2, and NO values appropriate to these categories.]

Acceptance Criteria: The EIS shall respond to each of the test conditions in accordance with the applicable requirements of this specification. Analyzer and dynamometer accuracy, response, response times, etc. shall remain within the tolerances allowed by this specification. No performance parameters of the EIS shall be degraded as a result of system integration.

5.12 CERTIFICATION TEST PROCEDURES: FIELD BETA TESTING

Manufacturers shall demonstrate that candidate systems, software, hardware, components and replacement parts meet the BAR-97 Specifications while operating in actual shop environment. During the beta demonstration, the EIS shall have all operational capabilities activated including connectivity with the VID.

The demonstration shall consist of a two-stage beta testing process in which the number of candidate units increases as successful testing progresses. Manufacturers must demonstrate the equipment continuously and correctly operates to BAR's satisfaction during the entire beta testing process. The beta test stations must be approved by BAR in advance and must agree to participate in the beta process. Station personnel shall be trained to conduct normal maintenance and calibrations.

The first stage consists of not more than ten units properly operating for a minimum of 2 weeks. Upon successfully completing stage one and with BAR's authorization, manufacturers may proceed to stage two. Stage two increases the number of units to between 50 and 100 and requires the successful operation of those units for a minimum of 8 weeks. Beta time may be shorter for minor changes as determined by BAR. During the beta demonstration, manufacturers shall provide field support and conduct weekly audits of the units. When applicable, the audits shall include a physical inspection of the sample system, the dynamometer and an evaluation of test and calibration records. The manufacturers shall provide BAR the weekly audit results.

See §4.9 for additional certification renewal requirements.

5.12.1 **Hexane/Propane Ratio**

Upon installation at the beta sites, the EIS units shall have the PEF measured, using the procedure in §5.4.7, but checking at only one point with High Range BAR-97 calibration gas. Record the data and provide it to BAR.

Repeat this PEF test on completion of the field beta test process, as the very last task before shutdown.

> **Acceptance Criteria:** The difference in PEF values from beginning to end of the field test shall be no more than 0.005.

5.12.2 **Calibration Monitoring**

Analyzer calibration shall be checked, but not adjusted (unless necessary), once a day at random times during the course of the day. The candidate unit shall be zeroed; then both Low and High BAR-97 blends shall be introduced through the probe (gas pressure at the probe tip ± 0.1 psig) and the readings recorded, along with the ambient temperature and the barometric pressure.

Acceptance Criteria: (1) The EIS shall require no unscheduled gas calibrations during the course of the field tests. (2) A failed leak check shall lock out the inspection mode.

5.12.3 **Inspections**

At least five inspections per day shall be performed on a variety of vehicles to exercise the EIS unit, the software and the procedures. Any problems encountered shall be brought to the attention of the BAR, and an analysis shall be made as to whether the cause is design-related or procedural. All EIS failures shall be investigated and a failure report submitted to BAR. Any flaws shall be corrected before full certification will be issued.